A 0.05 degree global climate/interdisciplinary long term data set from AVHRR, MODIS and VIIRS

PI & Co-I's:

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Collaborator: Chris Justice (UMD).

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Land Long Term Data Record

• Develop and produce a global long term coarse spatial resolution (0.05deg) data record from AVHRR, MODIS and VIIRS for use in global change and climate studies.

• Use a MODIS-like operational production approach including an operational QA team.

• Set up an advisory process.

• Make intermediate versions of the data sets available to the community through a web interface and solicit input from users.

• Hold community workshops for outreach and feedback.

• Prototype the development and production of a climate quality data record.

Proposed LTDR Products

AVHRR, MODIS, [VIIRS]:

VIS/NIR surface reflectance
MIR surface reflectance
Vegetation Indices
Surface temperature and emissivity
Snow
LAI/FPAR
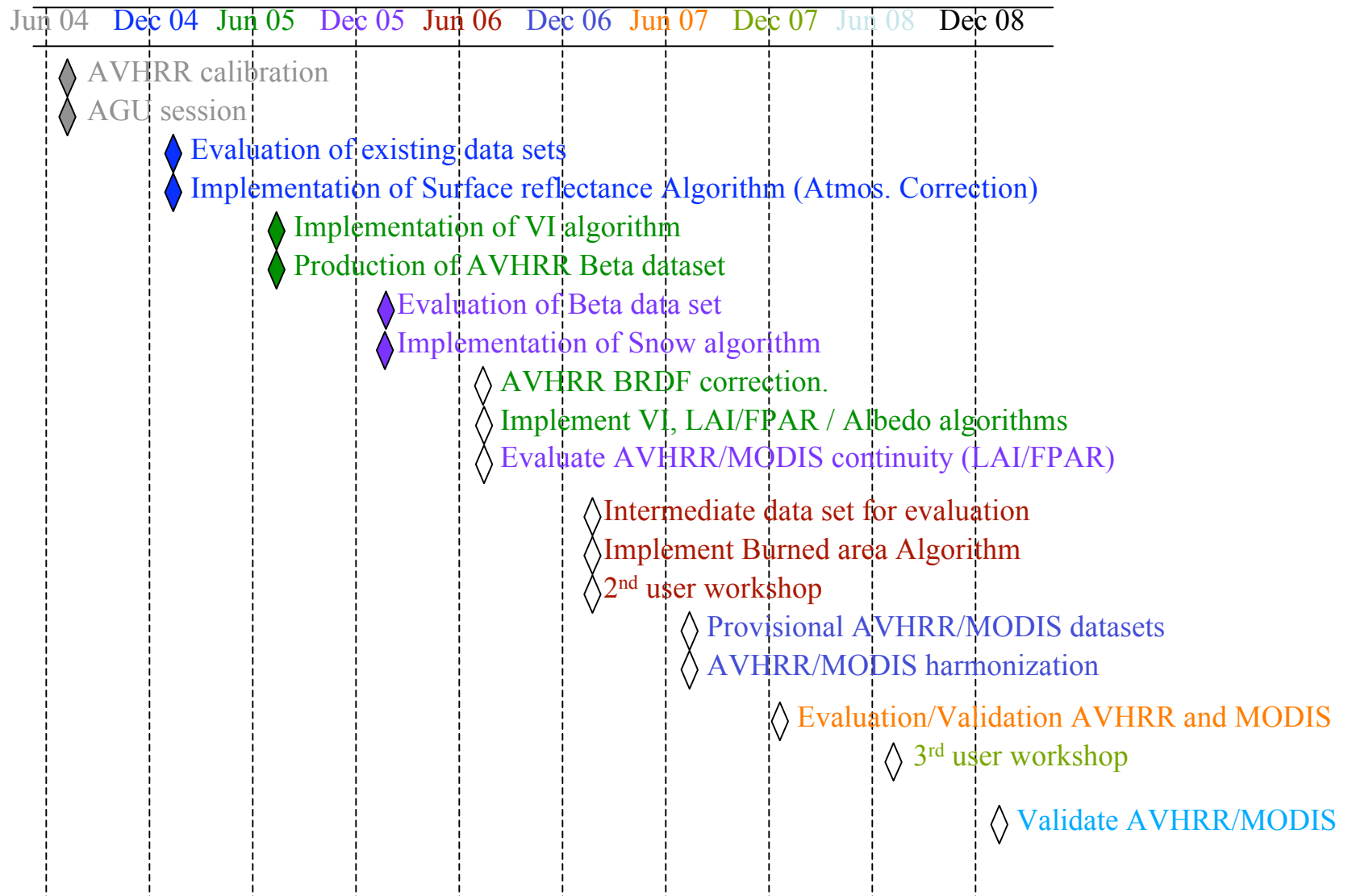BRDF/Albedo
Aerosols
Burned area

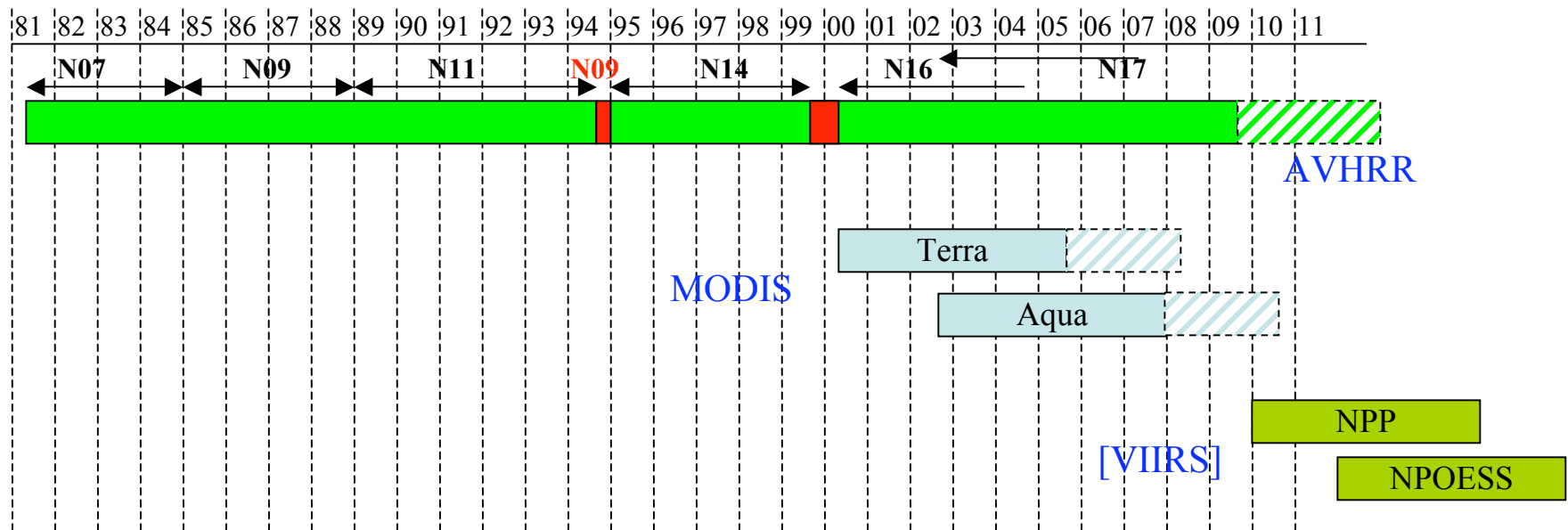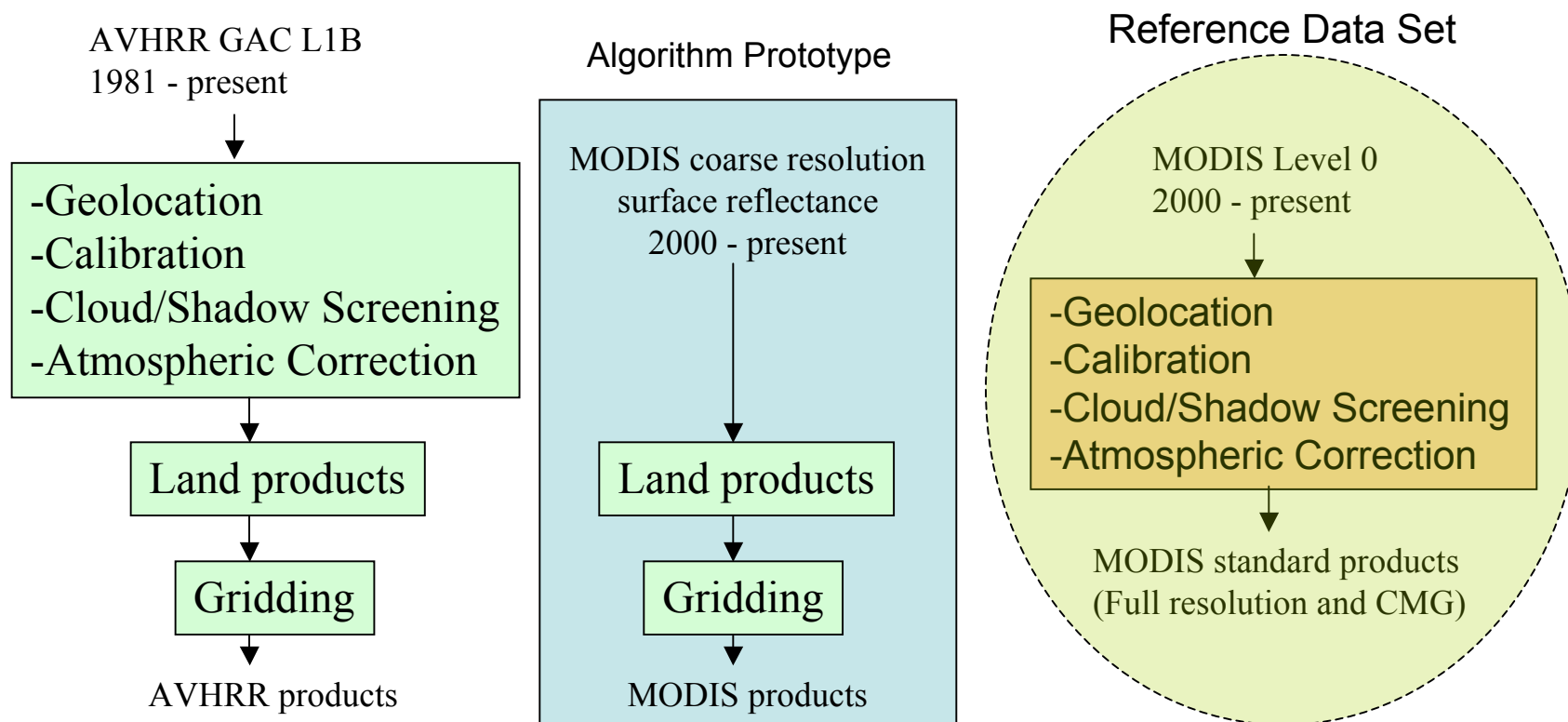Products and formats will be modified based on feedback from the User Community Workshops.

Project milestones

Jun 04   Dec 04   Jun 05   Dec 05   Jun 06   Dec 06   Jun 07   Dec 07   Jun 08   Dec 08

AVHRR calibration

AGU session

Evaluation of existing data sets

Implementation of Surface reflectance Algorithm (Atmos. Correction)

Implementation of VI algorithm

Production of AVHRR Beta dataset

Evaluation of Beta data set

Implementation of Snow algorithm

AVHRR BRDF correction.

Implement VI, LAI/FPAR / Albedo algorithms

Evaluate AVHRR/MODIS continuity (LAI/FPAR)

Intermediate data set for evaluation

Implement Burned area Algorithm

2nd user workshop

Provisional AVHRR/MODIS datasets

AVHRR/MODIS harmonization

Evaluation/Validation AVHRR and MODIS

3rd user workshop

Validate AVHRR/MODIS

Data Sources

AVHRR and MODIS Production Systems

AVHRR GAC L1B
1981 - present

- -Geolocation
- -Calibration
- -Cloud/Shadow Screening
- -Atmospheric Correction

Land products

Gridding

AVHRR products

Algorithm Prototype

MODIS coarse resolution
surface reflectance
2000 - present

Land products

Gridding

MODIS products

Reference Data Set

MODIS Level 0
2000 - present

- -Geolocation
- -Calibration
- -Cloud/Shadow Screening
- -Atmospheric Correction

MODIS standard products
(Full resolution and CMG)

List of potential products:
Surface Reflectance, VI,
Surface Temperature and emissivity,
Snow, LAI/FPAR, BRDF/Albedo,
Aerosols, burned area

Format:
HDF
Geographic projection 1/20 deg resolution
Daily, multi-day, monthly

Use of MODIS to improve AVHRR atmospheric corrections
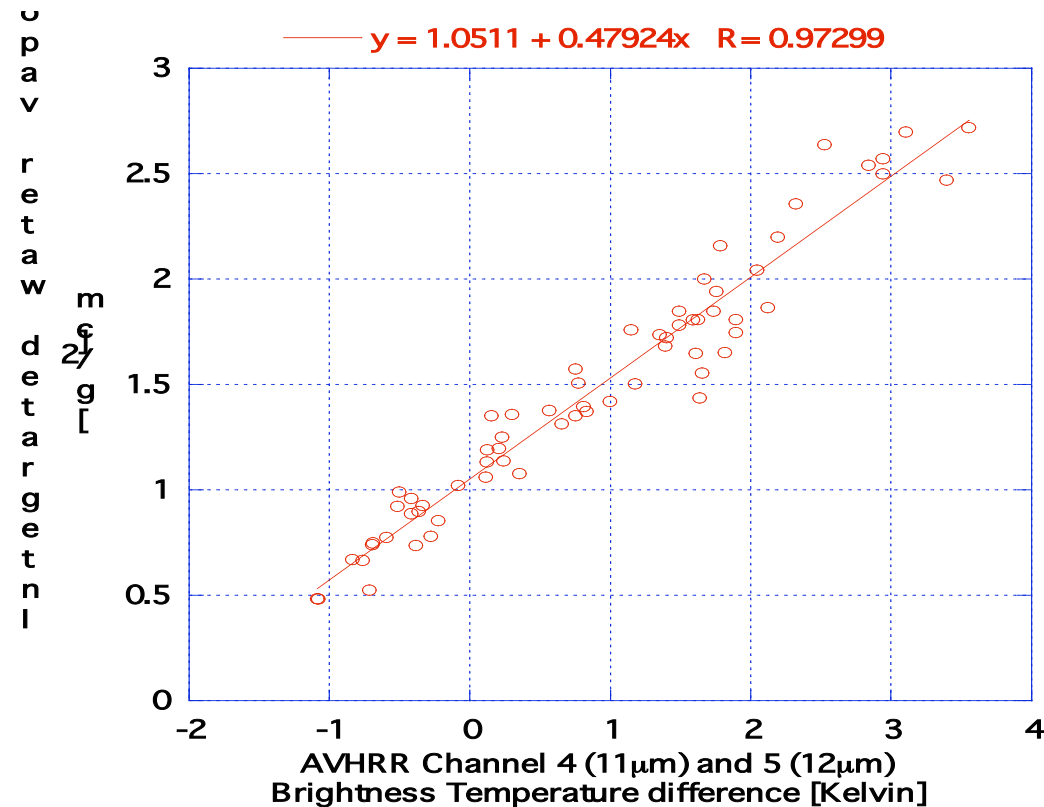
Use coincident MODIS/AVHRR data to develop an approach for water vapor retrieval from AVHRR.

Error Budget: AVHRR surface reflectance and NDVI summary

	AVHRR Pathfinder-like processing	With LTDR improvements
Calibration	10% absolute, 4% band to band	4% absolute, 2% band to band
Pressure	±10 mbars	±10 mbars
Water vapor	0.7 g.cm^{-2} (NCEP or None)	0.3 g.cm^{-2} (split window)
Ozone	±30 Dobson (LONDON)	±10 Dobson (EP-TOMS)
Aerosols	No Correction	0.01 error in predicting red refl. from 3.75 μm

Reflectance / NDVI	Forest value	Forest Aerosol Optical Depth clear	avg	hazy	Savanna value	Savanna Aerosol Optical Depth clear	avg	hazy	Semi-arid value	Semi-arid Aerosol Optical Depth clear	avg	hazy
ρ Ch1 (VIS)	8	6	0.051	3	6	0.009	7	0.073	3	9	0.039	8
ρ Ch2 (NIR)	0.237	0.020	7	8	6	4	5	0.037	7	9	0.02	9
ρ Ch3 (MIR)	0.045	0.002	6	1	6	2	4	6	3	3	4	4
NDVI	0.682	**0.033**	0.195	**0.266**	2	0.042	0.124	0.168	6	0.046	0.068	0.090
ρ Ch1 (VIS)	8	1	0.01	0.01	6	1	1	0.01	3	6	4	4
ρ Ch2 (NIR)	0.237	5	3	6	6	5	1	1	7	1	7	2
ρ Ch3 (MIR)	0.045	4	5	5	6	0	2	6	3	0.003	3	7
NDVI	0.682	0.056	0.058	**0.064**	2	0.043	0.047	0.054	6	**0.03**	0.033	0.038

The absolute calibration coefficients derived for NOAA-16 bands 1 and 2, using t were compared to the vicarious coefficients derived using the ocean and clouds (Vermote and Kaufman, 1995). The coefficients were consistent within less than A paper for RSE is in press.
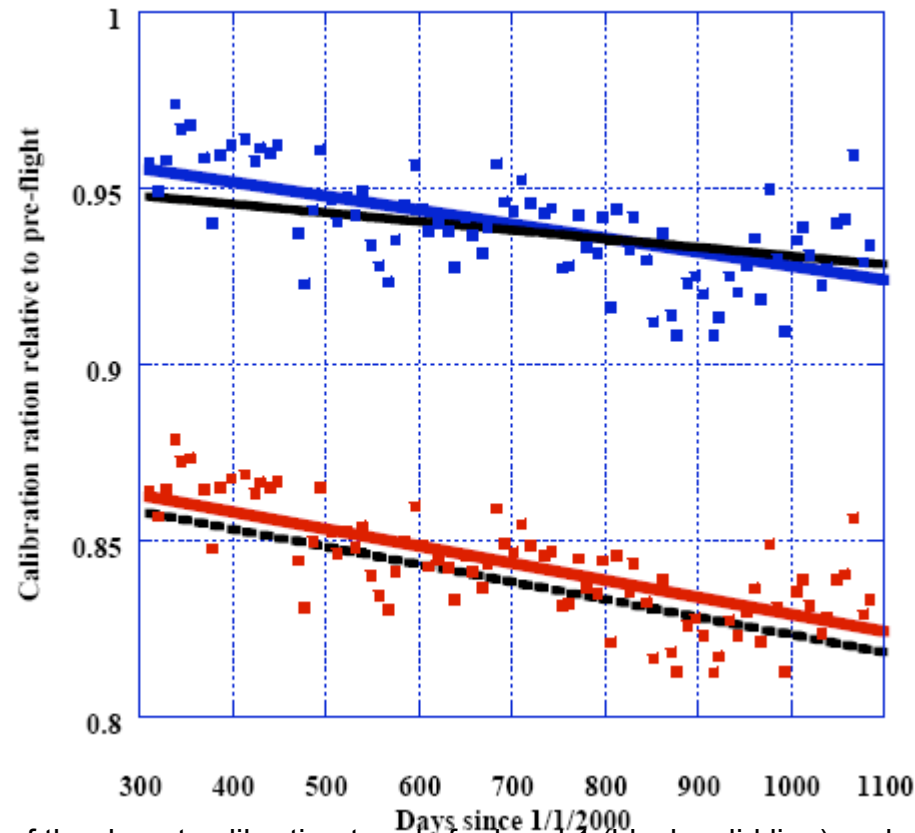
Comparison of the desert calibration trends for band 1 (black solid line) and
band 2 (black interrupted line), with the trends obtained using the Ocean and Clouds
method (Vermote and Kaufman, 1995) for band 1 (blue line and square) and band 2 (red
line and square).

Second year activities

- Produce an AVHRR surface reflectance and NDVI beta data set using Pathfinder 2 algorithms (vicarious calibration; Rayleigh, ozone and water vapor correction using ancillary data; aerosol retrieval over dark targets).

- Setup a web/ftp interface for data distribution.

- Identify a set of validation sites for use in the evaluation of the products.

- Evaluation of produced data set and start operational QA activity (global browse, known issues, time series monitoring and trends).

Second year activities (cont.)

- Develop code to process MODIS coarse resolution surface reflectance (MOD09CRS) into a data set with the same spatial and temporal characteristics as the AVHRR data set for use in evaluation and algorithm improvement.

- Start implementing LAI/FPAR, surface temperature and snow algorithms.

- Implement a community feedback mechanism to address users questions and to capture new requirements and concerns.

Second year activities (cont.)

•*Expand error budget analysis to include realistic scenarios (rather than worst case) and to account for temporal compositing.*
•*Use coincident MODIS and AVHRR data to improve aerosol retrieval and correction in AVHRR.*

Production of the Beta Data Set

- Algorithms:
  - Vicarious calibration (Vermote/Kaufman)
  - Cloud screening: CLAVR
  - Partial Atmospheric Correction:
    - Rayleigh (NCEP)
    - Ozone (TOMS)
    - Water Vapor (NCEP)
- Products:
  - Daily NDVI (AVH13C1)
  - Daily surface reflectance (AVH09C1)
  - 16-day composited NDVI (AVH13C3)
  - Monthly NDVI (AVH13CM)
- Format:
  - Linear Lat/Lon projection
  - Spatial resolution: 0.05 Deg
  - HDF-EOS
- Time Period:
  - 1981 – 2000 completed
- Archive and Distribution:
  - Over 1 TB stored online.
  - Distributed by ftp and web
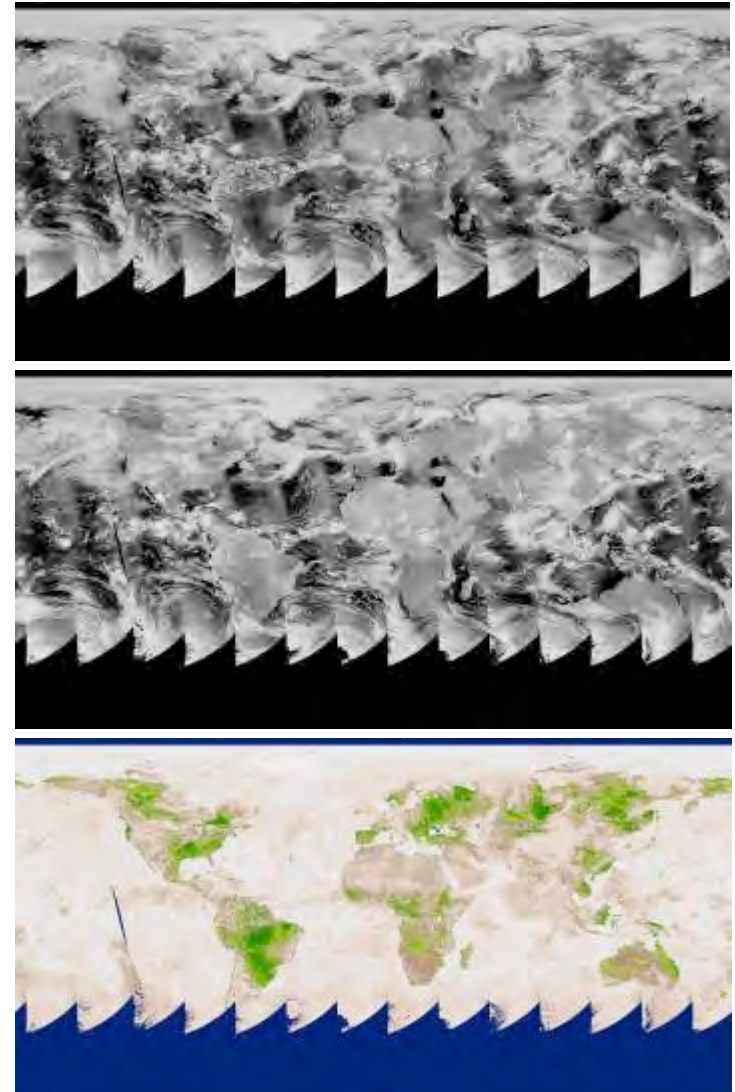
NOAA-11 - 1992193 (7/11/1992) : Ch1, Ch2 and NDVI

Data Set Evaluation

-Quality Assessment based on the MODIS Land approach (Devadiga/LDOPE)
 -Inspection of global browse images
 -Time series analysis

-Statistical analysis using non-linear tools (Pinzon/Tucker)
 -Verify the stability of the calibration
 -Comparison to GIMMS and Pathfinder data sets

-Verify theoretical errors using Aeronet data where available and develop
 product uncertainty estimates (Vermote/Nagol)

-Provided vicarious calibration coefficients to external users (NOAA/CSIRO)

-Beta users applications

Data Set Evaluation
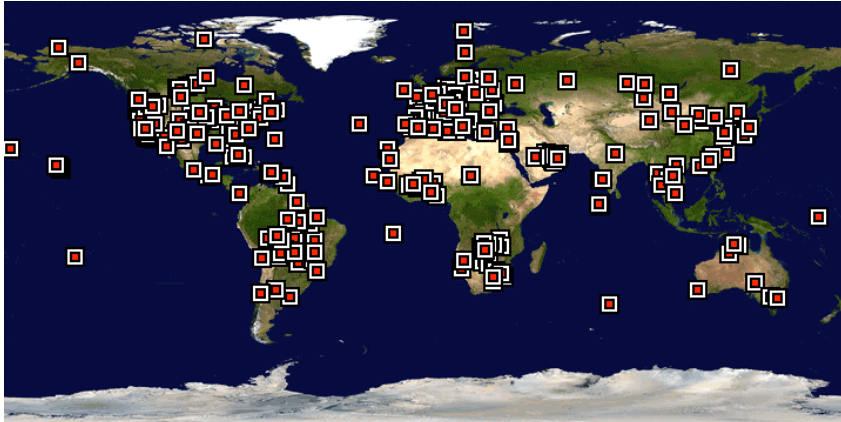
- 50x50 km cutouts centered on aeronet sites
- Surface reflectance and NDVI Time series plots posted on the QA webpage.
- Use aeronet AOT and WV measurement when available to assess errors due to lack of atmospheric correction.

BONDVILLE_1991-2000

Error in NDVI
Bondville
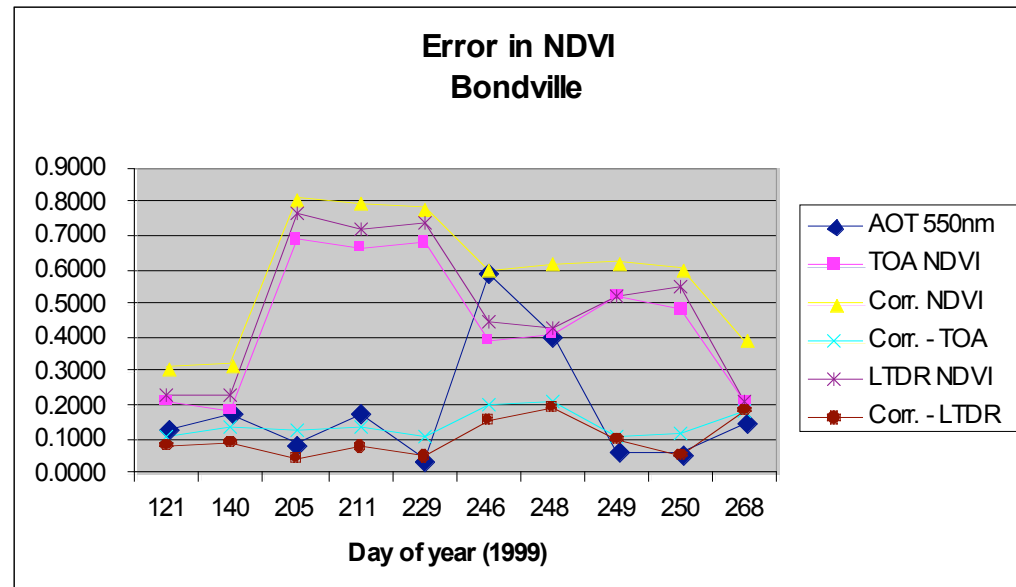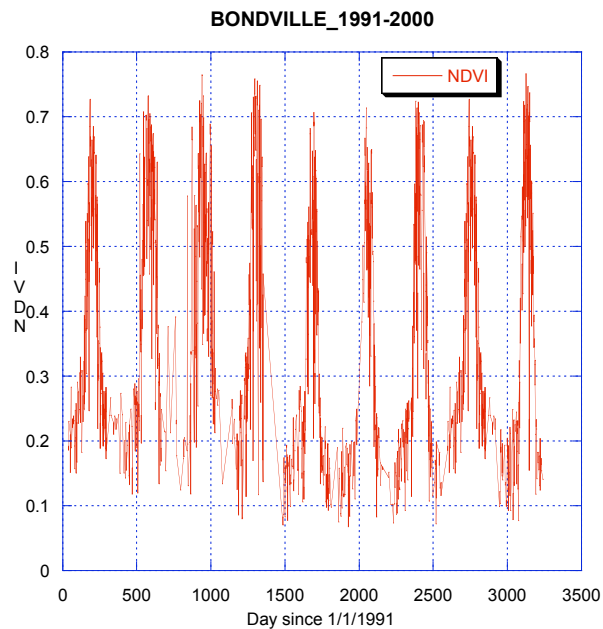
Evaluation goals (see MODIS poster's, Vermote,Saleous,Kotchenova
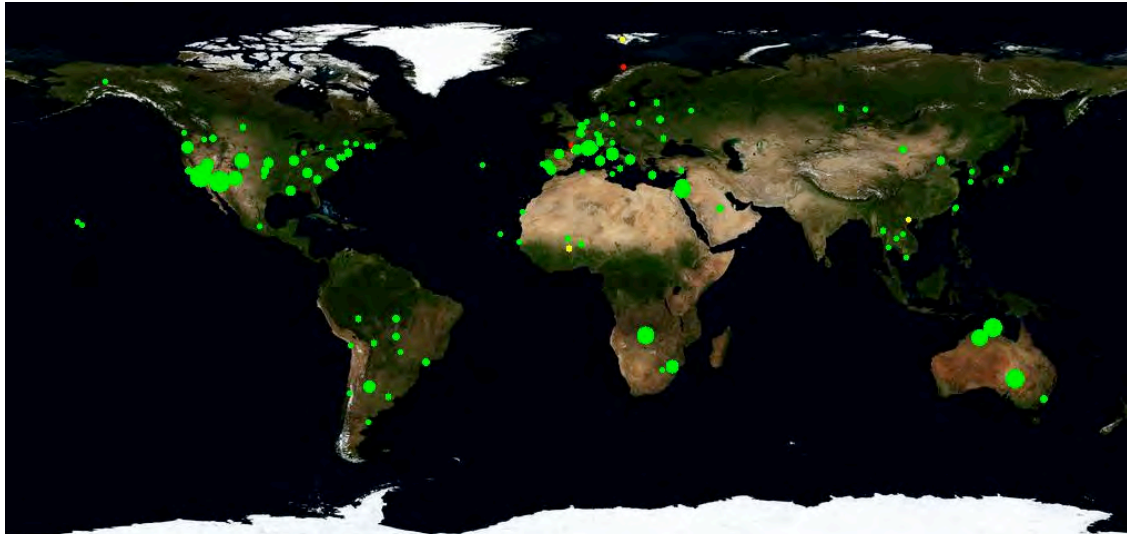
Reflectance/ VI	Forest				Savanna				Semi-arid			
	value	Aerosol Optical Depth			value	Aerosol Optical Depth			value	Aerosol Optical Depth		
		clear	avg	hazy		clear	avg	hazy		clear	avg	hazy
ρ3 (470 nm)	0.012	0.0052	0.0051	0.0052	0.04	0.0052	0.0052	0.0053	0.07	0.0051	0.0053	0.0055
ρ4 (550 nm)	0.0375	0.0049	0.0055	0.0064	0.0636	0.0052	0.0058	0.0064	0.1246	0.0051	0.007	0.0085
ρ1 (645 nm)	0.024	0.0052	0.0059	0.0065	0.08	0.0053	0.0062	0.0067	0.14	0.0057	0.0074	0.0085
ρ2 (870 nm)	0.2931	0.004	0.0152	0.0246	0.2226	0.0035	0.0103	0.0164	0.2324	0.0041	0.0095	0.0146
ρ5 (1240 nm)	0.3083	0.0038	0.011	0.0179	0.288	0.0038	0.0097	0.0158	0.2929	0.0045	0.0093	0.0148
ρ6 (1650 nm)	0.1591	0.0029	0.0052	0.0084	0.2483	0.0035	0.0066	0.0104	0.3085	0.0055	0.0081	0.0125
ρ7 (2130 nm)	0.048	0.0041	0.0028	0.0042	0.16	0.004	0.0036	0.0053	0.28	0.0056	0.006	0.0087
NDVI	0.849	0.03	0.034	0.04	0.471	0.022	0.028	0.033	0.248	0.011	0.015	0.019
EVI	0.399	0.005	0.006	0.007	0.203	0.003	0.005	0.005	0.119	0.002	0.004	0.004

Statistical Analysis
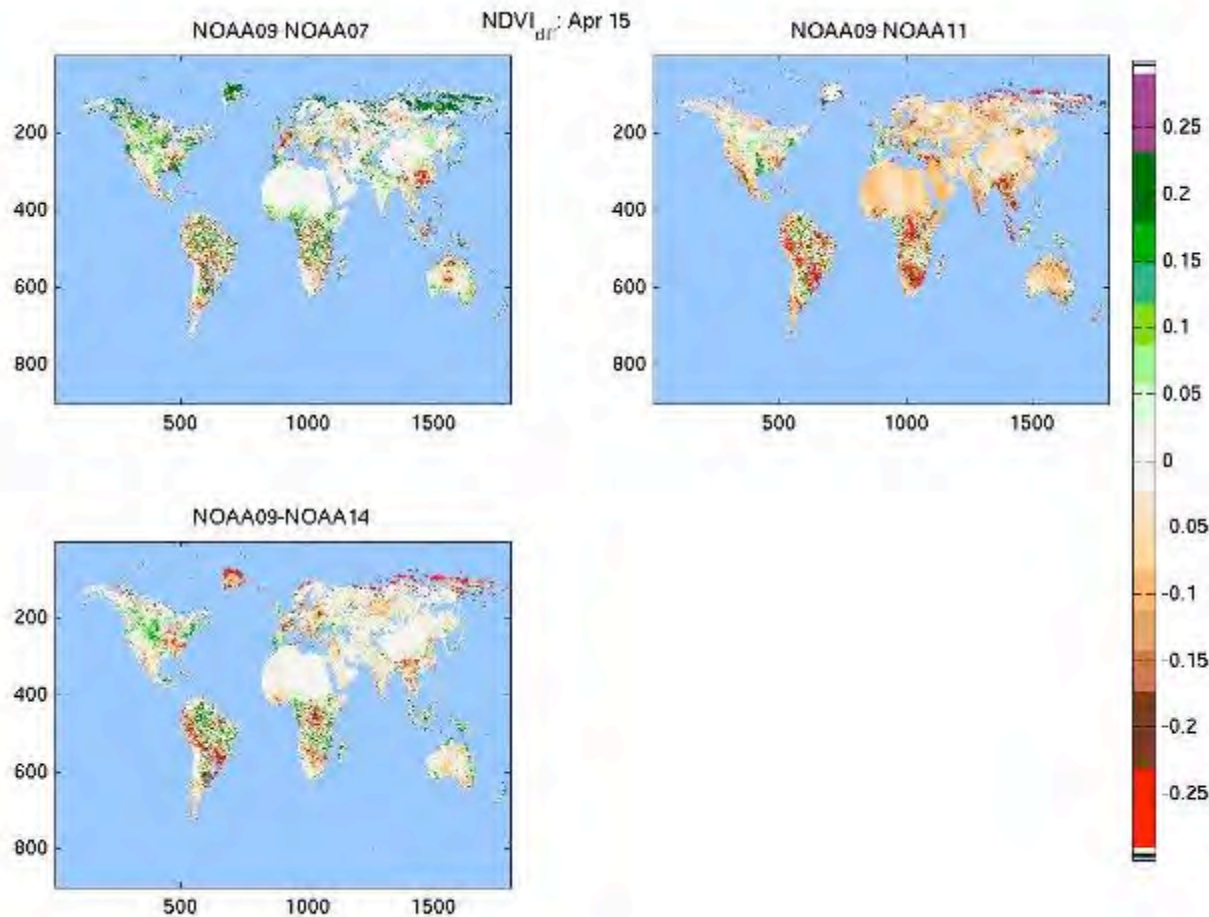
-Abnormally higher values in NOAA-11 over the desert were tracked to the use of incorrect calibration coefficients in production.
-Problem was also detected by the operational QA (time series) and is being corrected.

Beta Users

In addition to team members, certain users have been identified to use the beta data set in their applications:

-Andy Heidinger / Felix Kogan (NOAA) – Calibration

-Ed King (CSIRO) - Calibration

-Ranga Myneni (BU) - LAI

-Molly Brown (GSFC) - NDVI

-Marc Leroy (CESBIO/MediaFrance) : subset over East Africa : Evaluation of calibration and surface reflectance.

-Ana Pinheiro (GSFC) – Brightness/Surface temperature

-Menglin Jin (UMD) – Brightness/Surface temperature

-Users expressed interest in using the data set in EOS proposals
   -Anderson (BU)
   -Bounoua (GSFC)

LTDR Web Page

http://ltdr.nascom.nasa.gov/ltdr/ltdr.html

Operational Quality Assurance

Operational QA : Global Browse

Operational QA : Time Series

Abnormal behavior of NOAA-11
Due to wrong calibration

Unusable NOAA-14
data

Operational QA : Known Issues

SEEDS Activities

- Participated in the Reuse Working Group

- Participated in the Metrics Planning and Reporting Working Group (MPARWG)

Planned activities for the third year

- Complete evaluation of the beta data.
- Outreach activities
    - Vegetation workshop – Aug '06 Montana
    - Hold a special session at Fall'06 AGU to present results and get feedback.
    - MODIS Land Collection 5 workshop (Jan'07).
- Implement BRDF correction of AVHRR data to remove biases introduced by the orbital drift and changes in the solar and viewing geometries throughout the record.
- Complete implementation of LAI/FPAR and albedo algorithms.
- Compare AVHRR and MODIS data sets to quantify differences and to start addressing continuity issues (starting with higher order products).

Summary

Done:

-Created and started evaluating an AVHRR surface reflectance and NDVI Beta data set.

-Distributed the data set to selected beta users who will evaluate it in the context of their application.

-Posted the Beta data set and the associated QA webpage on the web.

-AVHRR vicarious calibration paper in review/revision.

To be done:

-Complete evaluation and comparison with Pathfinder and GIMMS data sets.

-Hold AGU session on Land Coarse Resolution Long Term Data Record.

-Implement LAI/FPAR and BRDF algorithms.

ESDR pathfinding

-This project provides a pathfinding activity for NASA's Land ESDRs with respect to inter-instrument calibration, product generation, QA and distribution.

- AVHRR data gaps
    -Two major data gaps exist in the AVHRR PM record.
        -The first one (end of 1994) can be filled using NOAA-09.
        -An option to fill the second one (1999->2000) requires the use of SPOT Vegetation data.

-The current project does not include collection and processing of AVHRR AM data. As with Terra and Aqua MODIS, AM and PM AVHRR data are useful for Thermal products and to improve BRDF retrievals.

-AVHRR on METOP will provide a longer overlap with MODIS.

-Obtaining and processing SPOT and METOP data require collaboration with foreign data producers. This provides an opportunity to test International cooperation in the creation of ESDRs.